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(54) Method and device for synchronising the boadcast frequency of two base stations

Verfahren und Vorrichtung zur Synchronisierung der Sendefrequenz zweier Basisstationen

Procédé et dispositif pour synchroniser la fréquence d'emission de deux stations de base

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- **PATENT ABSTRACTS OF JAPAN vol. 10, no. 76 (P-440) (2133) 26 March 1986 & JP-A-60 214 291 (NIPPON DENKI K. K.) 26 October 1985**
- **IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE AND EXHIBITION, vol.3, 1 December 1988, HOLLYWOOD,FLORIDA pages 1544 - 1548 W. GROVER ET. AL. 'Precision Time Transfer in Transport Networks using Digital Crossconnect Systems'**

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Description

[0001] This invention relates to devices and methods for synchronizing the broadcast frequency of a base station and a microcell. Such synchronization facilitates simulcasting of radio frequency channels.

[0002] A method of synchronizing clocks is taught in the prior art in J. Levine et al., "*The NIST Automated Computer Time Service*," Journal of Research of the National Institute of Standards and Technology Vol. 94, Number 5, p. 311 (Sept.-Oct. 1989). In that article, the authors explain the Automatic Computer Time Service (ACTS) which is a telephone time service designed to provide users with telephone access to time generated by the National Institute of Standards and Technology (NIST).

[0003] The article cites the principle limitation of time dissemination as being the uncertainty in the velocity of the propagation of the information through the medium separating the transmitter and the receiver. The delay, typically in the order of milliseconds, depends upon the physical length of the path and on the group velocity of the signal. Generally, neither of these parameters is known. Consequently, to achieve the highest degree of synchronization, real time measurements of the transit time must be taken.

[0004] The delay can be determined by measuring the time duration between transmitting a pulse to the user and receiving an echoed pulse. Half of this round trip delay is the time required for the signal to reach the user assuming that the communication medium is reciprocal. Although the article states that empirical evidence indicates reciprocity in telephone paths, it also maintains that the lack of perfect reciprocity may prove to be the ultimate limitation in the system.

[0005] To achieve this millisecond synchronization of computers, the NIST has developed a simple telephone system for the automated setting of clocks in digital systems. NIST has developed software to facilitate automatic dialing, selecting a time zone, selecting a mode of operation, echoing the on-time marker (OTM), setting of the computer clock, archiving of clock offset, and transmitting a signal to the parallel port of a computer, which can be used to produce an external time pulse coincident with the OTM. Additionally, the article provides diagrams of simple circuits to convert-the signal sent to the printer port to a positive pulse. The article also details a circuit that echoes all characters from the user and provides an external pulse when the OTM is received. This circuit requires a modem but does not require a computer.

[0006] The article basically focuses on the application of ACTS for the maintenance of accurate time within a digital computer. For example, the article suggests tagging business transactions or scientific data with the exact time. Such tagging becomes particularly useful where a multiplicity of computers independently tag events, and thus require a common time standard. Additionally, the article mentions a second application aimed at the measurement of frequency. In this application, the pulses coincident with the OTM are used to start and stop a counter. The counter counts the output of the oscillator under the test. By comparing the pulses to the counts, an oscillator can be calibrated using exact time. The system can be used to set digital clocks, or to perform frequency calibrations at an accuracy of one part in 10^8 for a one day period.

[0007] The article also speculates on the future development of the system and the new products which it might spawn. It suggests a digital clock comprising a microprocessor incorporated into a phone receiver. To maintain exact time according to the National Institute of Standards and Technology, the clock would access the ACTS via the telephone. Such a phone could be networked to other phones in a school or factory to provide the exact time throughout the organization. Additionally, the article suggests automatic calling to enable the user to call during less expensive non-peak hours.

[0008] Thus, the article limits the application of the method of synchronization to time -- both in the maintenance of accurate clocks and the calibration of frequency oscillators. The prior art lacks motivation to use the synchronization method in telecommunications. More specifically, the article does not suggest that the ACTS could be modified to enable a base station and a microcell to simulcast.

[0009] US-A-5059926 discloses the features recited in the preambles of claims 1 and 10, and relates to a method for synchronizing a slave oscillator with a master oscillator. The slave includes two counters driven by its oscillator. The master includes a system counter driven by its oscillator. The master sends a reset signal to the slave and the master simultaneously resets its system counter. Upon receipt of the reset signal, the slave resets its counters. The master also sends periodically to the slave a synchronization signal at predetermined intervals. Upon receipt of the synchronization signal, the slave modifies the value of its system counter based upon the closest multiple of the expected count value for the synchronisation signal interval. Further, at each synchronisation signal, the slave compares its system counter and reference counter and computes an oscillator error. The slave stores this value. The slave, depending on its mode of operation may use the stored oscillator error to warp its own oscillator at a future time.

[0010] US-A-4696052 discloses a simulcast transmission system having a central controller for controlling, via an interconnect link, the operation of each transmitter located at a plurality of base station sites. Periodically, the central controller outputs a resynchronization command via the interconnect link to the base stations. Each base station includes at least a transmitter having a transmit antenna and an adaptive-delay device. The adaptive-delay device consists of an adjustable delay and an intelligent sync comparator. This

adaptive-delay device with memory operates as a remotely-adjustable delay network upon receipt of a resync signal from the central controller and utilizes a reference sync signal derived from a master timing signal receiver to realize a uniform amount of time delay for each transmitter remotely-sited throughout the designated geographical area.

[0011] PATENT ABSTRACTS OF JAPAN vol. 10, no. 76 (P-440) (2133) 26 March 1986 & JP-A-60 214 291 (NIPPON DENKI K.K.) 26 October 1985 discloses a control system for adjusting a slave clock using evaluation information from a master clock.

[0012] At time T'O, the slave clock (SCL) sends a time information request signal TMD. The master clock MCL receives the TMD and sends a time information annunciation signal TMI back to the slave clock SCL at time T1. At time T'2, the slave clock SCL receives the TMI from the master clock MCL and calculates a time duration between the request time instant T'0 and the return time instant T'2 and divides this time duration in half in order to compute a transmission delay time DLTM. The slave clock SCL uses the time information and the determined transmission delay time DLTM from the master clock MCL to make a time adjustment.

[0013] According to one aspect of this invention there is provided a device as claimed in claim 1.

[0014] According to another aspect of this invention there is provided a method as claimed in claim 10.

[0015] The present invention is directed at enabling a base station and a microcell to simulcast. In particular, the present invention is aimed at synchronizing the oscillators located at the base station and the microcell when the two stations are joined by a metallic medium.

[0016] Embodiments of the invention may provide one or more of the following advantages.

[0017] By synchronizing the oscillator of the base station with the oscillator of the microcell the RF carriers synthesized at both the base station and the microcell will have the same frequency, thus facilitating simulcasting. Compensating for the transmission delay before the base station transmits a time-of-day signal not only facilitates simulcasting by providing the microcell with a real time reference, but also provides an absolute time standard for other functions at the microcell.

[0018] By maintaining a constant time delay between the transmission of the base station time-of-day signal and the microcell time-of-day signal the transmission delay between the base station and the microcell is negated, and the oscillators remain synchronized. Thus, simulcasting is facilitated.

[0019] By adjusting the base station's time-of-day signal to compensate for the time delay before it is transmitted to the microcell a real time reference is available to the microcell which enables it to simulcast.

[0020] The present invention teaches the circuitry required, as well as the method, to enable simulcasting of a base station and a microcell linked together by a metallic medium.

Brief Description of the Drawings

[0021] For a fuller understanding of the nature and object of the invention, the reader should take note of the detailed description taken in connection with the accompanying drawings in which:

Fig.1 depicts a preferred embodiment of the present invention.

Fig.2 shows another preferred embodiment which employs a compensation circuit.

Detailed Description of the Present Invention

[0022] In some applications of microcells known as simulcasting, it is necessary to transmit the same radio frequencies (RF) channels at the microcell site as those being transmitted at the base station. In areas where the RF signals overlap, mobile telephone units may receive both signals. Even a slight frequency difference between the signals is intolerable due to the beat notes produced. In a microcell system using optical fiber as the transmission medium between the base station and the microcell site, simulcasting is not a problem. The fiber can accommodate an extremely wide band width, thus making it possible to transmit the RF channels generated at the base station to the microcell site unmodified. In areas where fiber is not available or is too expensive to install, it would be advantages to use a metallic transport medium such as T1.

[0023] The problem with T1, however, is that due to its limited band width, a RF signal cannot be transported unmodified from the base station to the microcell. Instead, the RF signal -- a voice or data transmission --is modulated into an RF carrier generated at the microcell site. At both the base station and the microcell site, the RF carriers are synthesized using a reference frequency generated by an oscillator. However, to keep the microcell equipment small and inexpensive, it is impractical to use a high stability oscillator as is used at the base station; rather, a less expensive crystal reference oscillator is used. Some means is therefore needed to synchronize a crystal reference oscillator at the microcell site with the master oscillator at the base station. The present invention provides these means.

[0024] Referring now to Fig. 1, the schematic shows the present invention which enables a base broadcaster 3 and a microcell broadcaster 16 to "simulcast." Simulcasting, or broadcasting at the same frequency, requires synchronization of a base oscillator 1 located at a base station 31 and a microcell oscillator 12 located at a microcell 30. Base oscillator 1 -- which is typically a high stability oscillator such as rubidium -- provides a reference to a base RF carrier synthesizer 17, and a base clock 2 which outputs a base time-of-day signal. Microcell oscillator 12 is a crystal oscillator which can be adjusted by a digital controller 13 containing a micro-

processor. The output of microcell oscillator 12 is used as a reference frequency for both a microcell RF carrier synthesizer 15, and a microcell clock 14 which outputs a microcell time-of-day signal.

[0025] Base clock 2 periodically sends the base time-of-day signal to a base transmitter 4 which transmits it over metallic link 5 to microcell 30. At microcell 30, the base time-of-day signal is compared with the microcell time-of-day signal in a microcell comparer 11. Microcell comparer 11 periodically monitors the signals and calculates the time difference between the two signals. This time difference represents the accumulated error between base clock 2 and microcell clock 14 plus the transmission delay between base transmitter 4 and comparer 11. Since metallic link 5 imputes a constant transmission delay, the time difference should remain constant if base oscillator 1 and microcell oscillator 12 are synchronized. If, however, the time difference changes, the oscillators are not synchronized.

[0026] The change in time difference can be used to adjust microcell oscillator 12. More specifically, microcell comparer 11 sends a correction signal to digital controller 13 corresponding to the time difference change. Digital controller 13 in turn adjusts microcell oscillator 12 to bring the microcell time-of-day signal back within the constant transmission delay of metallic link 5. Thus, the frequency of microcell oscillator 12 can be brought arbitrarily close to the frequency of base oscillator 3.

[0027] Digital controller 13 not only adjusts microcell oscillator 12, but also resets microcell clock 14. Resetting microcell clock 14 may be required in the event of a power failure, or simply to match microcell clock 14 with base clock 2.

[0028] Fig. 2 depicts another preferred embodiment of the present invention. This particular embodiment comprises an automatic compensator circuit 33. When the time-of-day signal is sent over metallic link 5, there is a transmission delay before this signal reaches the microcell. This transmission delay is unpredictable due to uncertainties in the configuration of metallic link 5. The embodiment of Fig. 2, however, can overcome this problem.

[0029] A base transmitter 4 sends a pulse both to a delay processor 8, and along a metallic link 5 to a microcell transponder 6. Microcell transponder 6 echoes the pulse back to a base receiver 7, and base receiver sends a return signal to delay processor 8. Delay processor 8 measures the time duration between receiving the pulse from base transmitter 4 and receiving the return signal from base receiver 7. Delay processor 8 then divides this time duration in half to arrive at the transmission delay. This calculation represents the time required for a signal sent from base station 31 to reach microcell 30. To compensate for the transmission delay, delay processor 8 sends a delay signal to a delay adjuster 9 which advances the base time-of-day signal before base transmitter 4 transmits it to microcell comparer 11.

[0030] Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

Claims

1. A device for synchronizing the broadcast frequency of a base station (31) and a microcell (30) linked together by a metallic medium, comprising a base transmitter (4) for transmitting a base time-of-day signal to a microcell comparer (11); a microcell clock (14) for generating a microcell time-of-day signal, and sending the microcell time-of-day signal to a microcell comparer (11); and a microcell oscillator (12) for providing said microcell clock (14) with a microcell reference frequency, said device being characterized in that:

   (a) the microcell comparer (11) serves to calculate a time difference between the base time-of-day signal and the microcell time-of-day signal and to provide a correction signal based on the time difference to a digital controller (13);
   (b) the digital controller (13) serves to adjust said microcell oscillator (12) according to the correction signal; and there is provided
   (c) an automatic compensating circuit (33) comprising:

      (i) a microcell transponder (6) for receiving a pulse from said base transmitter (4) and echoing said pulse back to a base receiver (7); wherein
      (ii) the base receiver (7) serves to receive the echoed pulse from said microcell transponder (6), and sends a return signal to a delay processor (8);
      (iii) The delay processor (8) serves to calculate a time duration between the pulse transmitted by said base transmitter (4) and the return signal, to divide the time duration in half to arrive at a transmission delay, to generate a delay signal proportional to the transmission delay, and to send the delay signal to a delay adjuster (9); and
      (iv) the delay adjuster (9) serves to advance the base time-of-day signal to compensate for said transmission delay before said base transmitter (4) transmits the base time-of-day signal to said microcell comparer (11), wherein the automatic compensating circuit (33) compensates for said transmission delay by establishing a

first closed loop feedback path between the microcell (30) and the base station (31) via the base transmitter (4), the microcell transponder (6), the base receiver (7), the delay processor (8) and the delay adjuster (9), and a second closed loop feedback path via the base transmitter (4), the delay processor (8) and the delay adjuster (9), the second closed loop feedback path being contained within the first closed loop feedback path.

2. A device as claimed in claim 1 wherein the correction signal is proportional to a change in the time difference, and said digital controller (13) serves to adjust said microcell oscillator (12) to maintain a constant time difference.

3. A device as claimed in claim 1 wherein said digital controller (13) comprises circuitry to periodically reset said microcell clock (14) to match the base time-of-day signal by compensating for the time difference.

4. A device as claimed in claim 1 wherein the correction signal is proportional to the time difference, and said digital controller (13) serves to adjust said microcell oscillator (12) to reduce the time difference to zero.

5. A device as claimed in claim 1 wherein said digital controller (13) comprises circuitry to reset said microcell clock (14) in the event of a power failure.

6. A device as claimed in claim 1 wherein said digital controller (13) comprises circuitry to periodically reset said microcell clock (14) to match the base time-of-day signal as modified by said delay adjuster (9).

7. A device as claimed in claim 1 wherein said microcell oscillator (12) comprises a crystal type oscillator.

8. A device as claimed in claim 1 comprising:

a base oscillator (1) for providing a base reference frequency to both a base clock (2) and a base RF carrier synthesizer (17); wherein
the base clock (2) serves to receive the base reference frequency from said base oscillator (1) and to provide the base time-of-day signal to said base transmitter (4); and
the base RF carrier synthesizer (17) serves to receive the base reference frequency from said base oscillator (1) and to provide a base broadcasting signal to a base broadcaster (3).

9. A device as claimed in claim 8 wherein said base oscillator (1) comprises a high stability, rubidium type oscillator.

10. A method for synchronizing the broadcast frequency of a base station (31) and a microcell (30) linked together by a metallic medium, comprising the steps of transmitting a base time-of-day signal generated by a base oscillator (1) to a microcell comparer (11) by a base transmitter (4); sending a microcell time-of-day signal generated by a microcell oscillator (12) to said microcell comparer (11); and calculating a time difference of the base time-of-day signal with the microcell time-of-day signal via said microcell comparer (11), said method being characterized by the steps of:

(a) sending a correction signal from said microcell comparer (11) to a digital controller (13), said correction signal corresponding to a change in the time difference;
(b) adjusting said microcell oscillator (12) via a digital controller (13) to maintain a constant time difference; and
(c) automatically compensating via an automatic compensating circuit (33) comprising:

(i) a microcell transponder (6) for receiving a pulse from said base transmitter (4) and echoing said pulse back to a base receiver (7); wherein
(ii) the base receiver (7) receives the echoed pulse from said microcell transponder (6), and sends a return signal to a delay processor (8);
(iii) the delay processor (8) calculates a time duration between the pulse and the return signal, divides the time duration in half to arrive at a transmission delay, generates a delay signal proportional to the transmission delay, and sends the delay signal to a delay adjuster (9); and,
(iv) the delay adjuster (9) advances the base time-of-day signal to compensate for said transmission delay before said base transmitter (4) transmits the base time-of-day signal to said microcell comparer (11), wherein the automatic compensating circuit (33) compensates for said transmission delay by establishing a first closed loop feedback path between the microcell (30) and the base station (31) via the base transmitter (4), the microcell transponder (6), the base receiver (7), the delay processor (8) and the delay adjuster (9), and a second closed loop feedback path via the base transmitter (4), the delay processor (8) and the delay adjuster (9), the second

closed loop feedback path being contained within the first closed loop feedback path.

11. A method as claimed in claim 10 comprising:

(d) resetting said microcell clock (14) via said digital controller (13) to match the microcell time-of-day signal to the base time-of-day signal while compensating for the time difference.

12. A method as claimed in claim 10 comprising:

(d) resetting said microcell clock (14) via said digital controller (13) in the event of a power outage.

Patentansprüche

1. Einrichtung zum Synchronisieren der Rundsendefrequenz einer Basisstation (31) und einer Mikrozelle (30), die durch ein metallisches Medium miteinander verbunden sind, umfassend einen Basissender (4) zum Senden eines Basis-Tageszeitsignals zu einem Mikrozellen-Vergleicher (11); einen Mikrozellentakt (14) zum Erzeugen eines Mikrozellen-Tageszeitsignals und zum Senden des Mikrozellen-Tageszeitsignals zu einem Mikrozellen-Vergleicher (11); und einen Mikrozellen-Oszillator (12) zum Bereitstellen des Mikrozellentakts (14) mit einer Mikrozellen-Bezugsfrequenz, wobei die Einrichtung durch folgendes gekennzeichnet ist:

(a) der Mikrozellen-Vergleicher (11) dient zum Berechnen einer Zeitdifferenz zwischen dem Basis-Tageszeitsignal und dem Mikrozellen-Tageszeitsignal und zum Bereitstellen eines Korrektursignals auf der Grundlage der Zeitdifferenz für eine digitale Steuerung (13);
(b) die digitale Steuerung (13) dient zum Einstellen des Mikrozellen-Oszillators (12) gemäß dem Korrektursignal; und es ist folgendes bereitgestellt:
(c) eine automatische Kompensationsschaltung (33) umfassend:

(i) einen Mikrozellen-Transponder (6) zum Empfangen eines Impulses aus dem Basissender (4) und zum Zurücksenden eines Echos des Impulses zu einem Basisempfänger (7); wobei
(ii) der Basisempfänger (7) zum Empfangen des Echos des Impulses aus dem Mikrozellen-Transponder (6) dient und ein Rücksignal zu einem Verzögerungsprozessor (8) sendet;
(iii) der Verzögerungsprozessor (8) zum Berechnen einer Zeitdauer zwischen dem durch den Basissender (4) gesendeten Impuls und dem Rücksignal dient, um die Zeitdauer durch Zwei zu teilen, um zu einer Durchlaufverzögerung zu gelangen, um ein Verzögerungssignal zu erzeugen, das proportional zu der Durchlaufverzögerung ist, und das Verzögerungssignal zu einem Verzögerungseinstellglied (9) zu senden; und
(iv) das Verzögerungseinstellglied (9) zum Vorrücken des Basis-Tageszeitsignals dient, um die Durchlaufverzögerung zu kompensieren, bevor der Basissender (4) das Basis-Tageszeitsignal zu dem Mikrozellen-Vergleicher (11) sendet, wobei die automatische Kompensationsschaltung (33) die Durchlaufverzögerung kompensiert, indem ein erster geschlossener Rückkopplungsweg zwischen der Mikrozelle (30) und der Basisstation (31) über den Basissender (4), den Mikrozellen-Transponder (6), den Basisempfänger (7), den Verzögerungsprozessor (8) und das Verzögerungseinstellglied (9) hergestellt wird und ein zweiter geschlossener Rückkopplungsweg über den Basissender (4), den Verzögerungsprozessor (8) und das Verzögerungseinstellglied (9) hergestellt wird, wobei der zweite geschlossene Rückkopplungsweg in dem ersten geschlossenen Rückkopplungsweg enthalten ist.

2. Einrichtung nach Anspruch 1, wobei das Korrektursignal proportional zu einer Änderung der Zeitdifferenz ist, wobei die digitale Steuerung (13) zum Einstellen des Mikrozellen-Oszillators (12) dient, um eine konstante Zeitdifferenz aufrechtzuerhalten.

3. Einrichtung nach Anspruch 1, wobei die digitale Steuerung (13) Schaltkreise zum periodischen Rücksetzen des Mikrozellentakts (14) umfasst, um das Basis-Tageszeitsignal durch Kompensieren der Zeitdifferenz anzupassen.

4. Einrichtung nach Anspruch 1, wobei das Korrektursignal proportional zu der Zeitdifferenz ist und die digitale Steuerung (13) zum Einstellen des Mikrozellen-Oszillators (12) dient, um die Zeitdifferenz auf Null zu reduzieren.

5. Einrichtung nach Anspruch 1, wobei die digitale Steuerung (13) Schaltkreise zum Rücksetzen des Mikrozellentakts (14) im Fall eines Stromausfalls umfasst.

6. Einrichtung nach Anspruch 1, wobei die digitale Steuerung (13) Schaltkreise zum periodischen Rücksetzen des Mikrozellentakts (14) umfasst, um

das durch das Verzögerungseinstellglied (9) modifizierte Basis-Tageszeitsignal anzupassen.

7. Einrichtung nach Anspruch 1, wobei der Mikrozellen-Oszillator (12) einen Kristalloszillator umfasst.

8. Einrichtung nach Anspruch 1, umfassend:

einen Basisoszillator (1) zum Bereitstellen einer Basis-Bezugsfrequenz sowohl für einen Basistakt (2) als auch für einen Basis-HF-Trägersynthesizer (17); wobei
der Basistakt (2) zum Empfangen der Basis-Bezugsfrequenz aus dem Basisoszillator (1) und zum Bereitstellen eines Basis-Tageszeitsignals für den Basissender (4) dient; und
der Basis-HF-Trägersynthesizer (17) zum Empfangen der Basis-Bezugsfrequenz aus dem Oszillator (1) und zum Bereitstellen eines Basis-Rundsendesignals für einen Basis-Rundsender (3) dient.

9. Einrichtung nach Anspruch 8, wobei der Basisoszillator (1) einen hochstabilen Rubidiumoszillator umfasst.

10. Verfahren zum Synchronisieren der Rundsendefrequenz einer Basisstation (31) und einer Mikrozelle (30), die durch ein metallisches Medium miteinander verbunden sind, umfassend die Schritte Senden, durch einen Basissender (4), eines durch einen Basisoszillator (1) erzeugten Basis-Tageszeitsignals zu einem Mikrozellen-Vergleicher (11); Senden eines durch einen Mikrozellen-Oszillator (12) erzeugten Mikrozellen-Tageszeitsignals zu dem Mikrozellen-Vergleicher (11); und Berechnen einer Zeitdifferenz des Basis-Tageszeitsignals mit dem Mikrozellen-Tageszeitsignal über den Mikrozellen-Vergleicher (11), wobei das Verfahren durch die folgenden Schritte gekennzeichnet ist:

(a) Senden eines Korrektursignals aus dem Mikrozellen-Vergleicher (11) zu einer digitalen Steuerung (13), wobei das Korrektursignal einer Änderung der Zeitdifferenz entspricht;
(b) Einstellen des Mikrozellen-Oszillators (12) über eine digitale Steuerung (13) zur Aufrechterhaltung einer konstanten Zeitdifferenz; und
(c) automatisches Kompensieren über eine automatische Kompensationsschaltung (33), umfassend:

(i) einen Mikrozellen-Transponder (6) zum Empfangen eines Impulses aus den Basissender (4) und zum Zurücksenden eines Echos des Impulses zu einem Basisempfänger (7); wobei
(ii) der Basisempfänger (7) das Echo des Impulses aus dem Mikrozellen-Transponder (6) empfängt und ein Rücksignal zu einem Verzögerungsprozessor (8) sendet;
(iii) der Verzögerungsprozessor (8) eine Zeitdauer zwischen dem Impuls und dem Rücksignal berechnet, die Zeitdauer durch Zwei zu teilt, um zu einer Durchlaufverzögerung zu gelangen, ein Verzögerungssignal erzeugt, das proportional zu der Durchlaufverzögerung ist, und das Verzögerungssignal zu einem Verzögerungseinstellglied (9) sendet; und
(iv) das Verzögerungseinstellglied (9) das Basis-Tageszeitsignal vorrückt, um die Durchlaufverzögerung zu kompensieren, bevor der Basissender (4) das Basis-Tageszeitsignal zu dem Mikrozellen-Vergleicher (11) sendet, wobei die automatische Kompensationsschaltung (33) die Durchlaufverzögerung kompensiert, indem ein erster geschlossener Rückkopplungsweg zwischen der Mikrozelle (30) und der Basisstation (31) über den Basissender (4), den Mikrozellen-Transponder (6), den Basisempfänger (7), den Verzögerungsprozessor (8) und das Verzögerungseinstellglied (9) hergestellt wird und ein zweiter geschlossener Rückkopplungsweg über den Basissender (4), den Verzögerungsprozessor (8) und das Verzögerungseinstellglied (9) hergestellt wird, wobei der zweite geschlossene Rückkopplungsweg in dem ersten geschlossenen Rückkopplungsweg enthalten ist.

11. Verfahren nach Anspruch 10, umfassend:

(d) Rücksetzen des Mikrozellentakts (14) über die digitale Steuerung (13) zur Anpassung des Mikrozellen-Tageszeitsignals an das Basis-Tageszeitsignal, während die Zeitdifferenz kompensiert wird.

12. Verfahren nach Anspruch 10, umfassend:

(d) Rücksetzen des Mikrozellentakts (14) über die digitale Steuerung (13) im Fall eines Stromausfalls.

Revendications

1. Dispositif pour synchroniser la fréquence de diffusion d'une station de base (31) et d'une microcellule (30) reliées par un milieu métallique, comprenant un émetteur de base (4) pour émettre un signal d'heure de base vers un comparateur de microcellule (11) ; une horloge de microcellule (14)

pour générer un signal d'heure de microcellule, et envoyer le signal d'heure de microcellule à un comparateur de microcellule (11) ; et un oscillateur de microcellule (12) pour fournir à ladite horloge de microcellule (14) une fréquence de référence de microcellule, ledit dispositif étant caractérisé en ce que :

(a) le comparateur de microcellule (11) sert à calculer une différence de temps entre le signal d'heure de base et le signal d'heure de microcellule et à fournir à un contrôleur numérique (13) un signal de correction en fonction de la différence de temps ;
(b) le contrôleur numérique (13) sert à régler ledit oscillateur de microcellule (12) conformément au signal de correction ; et en ce qu'est fourni
(c) un circuit de compensation automatique (33) comprenant :

(i) un transpondeur de microcellule (6) pour recevoir une impulsion à partir dudit émetteur de base (4) et renvoyer ladite impulsion à un récepteur de base (7) ; dans lequel
(ii) le récepteur de base (7) sert à recevoir l'impulsion renvoyée par ledit transpondeur de microcellule (6), et envoie un signal de retour à un processeur de retard (8) ;
(iii) le processeur de retard (8) sert à calculer une durée de temps entre l'impulsion émise par ledit émetteur de base (4) et le signal de retour, à diviser de moitié la durée de temps en vue d'aboutir à un retard de transmission, à générer un signal de retard proportionnel au retard de transmission, et à envoyer le signal de retard à un circuit de réglage de retard (9) ; et
(iv) le circuit de réglage de retard (9) sert à avancer le signal d'heure de base en vue de compenser ledit retard de transmission avant que ledit émetteur de base (4) n'émette le signal d'heure de base vers ledit comparateur de microcellule (11), dans lequel le circuit de compensation automatique (33) compense ledit retard de transmission en établissant un premier trajet de boucle de contre-réaction fermée entre la microcellule (30) et la station de base (31) par l'intermédiaire de l'émetteur de base (4), du transpondeur de microcellule (6), du récepteur de base (7), du processeur de retard (8) et du circuit de réglage de retard (9), et un deuxième trajet de boucle de contre-réaction fermée par l'intermédiaire de l'émetteur de base (4), du processeur de base (8) et du circuit de réglage de retard (9), le deuxième trajet de boucle de contre-réaction fermée étant contenu à l'intérieur dudit premier trajet de boucle de contre-réaction fermée.

2. Dispositif selon la revendication 1, dans lequel le signal de correction est proportionnel à un changement de la différence de temps, et ledit contrôleur numérique (13) sert à régler ledit oscillateur de microcellule (12) en vue de maintenir une différence de temps constante.

3. Dispositif selon la revendication 1, dans lequel ledit contrôleur numérique (13) comprend des circuits pour périodiquement remettre à zéro ladite horloge de microcellule (14) en vue de la faire correspondre au signal d'heure de base en compensant la différence de temps.

4. Dispositif selon la revendication 1, dans lequel le signal de correction est proportionnel à la différence de temps, et ledit contrôleur numérique (13) sert à régler ledit oscillateur de microcellule (12) en vue de réduire la différence de temps à zéro.

5. Dispositif selon la revendication 1, dans lequel ledit contrôleur numérique (13) comprend des circuits pour remettre à zéro ladite horloge de microcellule (14) en cas de panne d'alimentation.

6. Dispositif selon la revendication 1, dans lequel ledit contrôleur numérique (13) comprend des circuits pour périodiquement remettre à zéro ladite horloge de microcellule (14) en vue de la faire correspondre au signal d'heure de base tel que modifié par ledit circuit de réglage de retard (9).

7. Dispositif selon la revendication 1, dans lequel ledit oscillateur de microcellule (12) comprend un oscillateur du type à quartz.

8. Dispositif selon la revendication 1, comprenant :

un oscillateur de base (1) pour fournir une fréquence de référence de base à la fois à une horloge de base (2) et à un synthétiseur de porteuse RF de base (17) ; dans lequel
l'horloge de base (2) sert à recevoir la fréquence de référence de base à partir dudit oscillateur de base (1) et à fournir le signal d'heure de base audit émetteur de base (4) ; et
le synthétiseur de porteuse RF de base (17) sert à recevoir la fréquence de référence de base à partir dudit oscillateur de base (1) et à fournir un signal de diffusion de base à un diffuseur de base (3).

9. Dispositif selon la revendication 8, dans lequel ledit

oscillateur de base (1) comprend un oscillateur du type à rubidium, de haute stabilité.

10. Procédé pour synchroniser la fréquence de diffusion d'une station de base (31) et d'une microcellule (30) reliées par un milieu métallique, comprenant les étapes d'émission d'un signal d'heure de base généré par un oscillateur de base (1) vers un comparateur de microcellule (11) par un émetteur de base ; d'envoi d'un signal d'heure de microcellule généré par un oscillateur de microcellule (12) audit comparateur de microcellule (11) ; et de calcul d'une différence de temps du signal d'heure de base avec le signal d'heure de microcellule par l'intermédiaire dudit comparateur de microcellule (11), ledit procédé étant caractérisé par les étapes de :

(a) envoi d'un signal de correction par ledit comparateur de microcellule (11) à un contrôleur numérique (13), ledit signal de correction correspondant à un changement de la différence de temps ;
(b) réglage dudit oscillateur de microcellule (12) par l'intermédiaire d'un contrôleur numérique (13) pour maintenir une différence de temps constante ; et
(c) compensation automatique par l'intermédiaire d'un circuit de compensation automatique (33) comprenant :

(i) un transpondeur de microcellule (6) pour recevoir une impulsion à partir dudit émetteur de base (4) et renvoyer ladite impulsion à un récepteur de base (7) ; dans lequel
(ii) le récepteur de base (7) reçoit l'impulsion renvoyée par ledit transpondeur de microcellule (6), et envoie un signal de retour à un processeur de retard (8) ;
(iii) le processeur de retard (8) calcule une durée de temps entre l'impulsion et le signal de retour, divise de moitié la durée de temps en vue d'aboutir à un retard de transmission, génère un signal de retard proportionnel au retard de transmission, et envoie le signal de retard à un circuit de réglage de retard (9) ; et
(iv) le circuit de réglage de retard (9) avance le signal d'heure de base en vue de compenser ledit retard de transmission avant que ledit émetteur de base (4) n'émette le signal d'heure de base vers ledit comparateur de microcellule (11), dans lequel le circuit de compensation automatique (33) compense ledit retard de transmission en établissant un premier trajet de boucle de contre-réaction fermée entre la microcellule (30) et la station de base (31) par l'intermédiaire de l'émetteur de base (4), du transpondeur de microcellule (6), du récepteur de base (7), du processeur de retard (8) et du circuit de réglage de retard (9), et un deuxième trajet de boucle de contre-réaction fermée par l'intermédiaire de l'émetteur de base (4), du processeur de base (8) et du circuit de réglage de retard (9), le deuxième trajet de boucle de contre-réaction fermée étant contenu à l'intérieur dudit premier trajet de boucle de contre-réaction fermée.

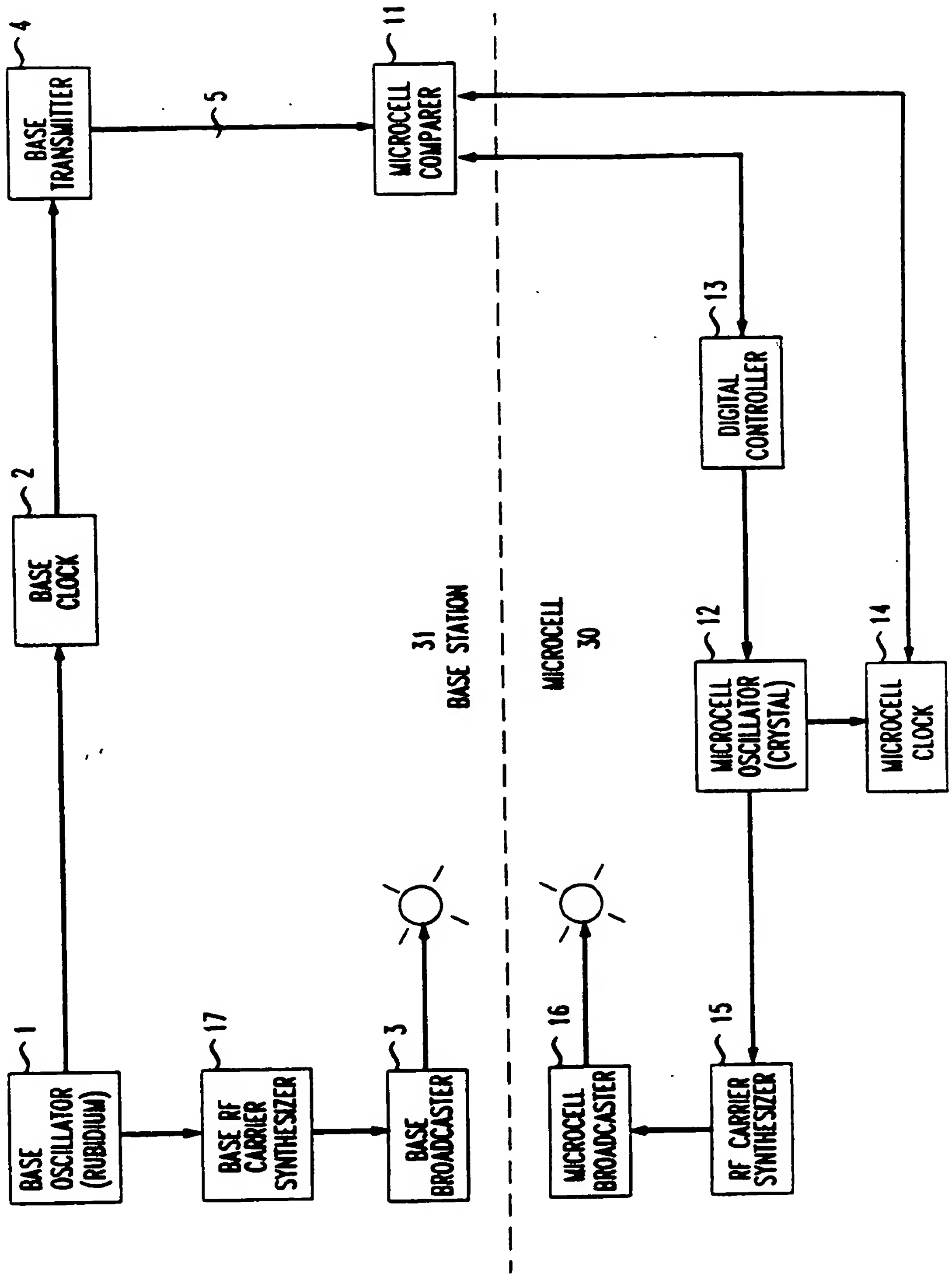
11. Procédé selon la revendication 10, comprenant :

(d) la remise à zéro de ladite horloge de microcellule (14) par l'intermédiaire dudit contrôleur numérique (13) en vue de faire correspondre le signal d'heure de microcellule au signal d'heure de base en compensant la différence de temps.

12. Procédé selon la revendication 10, comprenant :

(d) la remise à zéro de ladite horloge de microcellule (14) par l'intermédiaire dudit contrôleur numérique (13) en cas de panne d'alimentation.

FIG. 1


BASE OSCILLATOR (RUBIDIUM)
1
BASE RF CARRIER SYNTHESIZER
17
BASE BROADCASTER
3
BASE CLOCK
2
BASE TRANSMITTER
4
5
MICROCELL COMPARER
11
31
BASE STATION
MICROCELL
30
DIGITAL CONTROLLER
13
MICROCELL OSCILLATOR (CRYSTAL)
12
MICROCELL CLOCK
14
RF CARRIER SYNTHESIZER
15
MICROCELL BROADCASTER
16

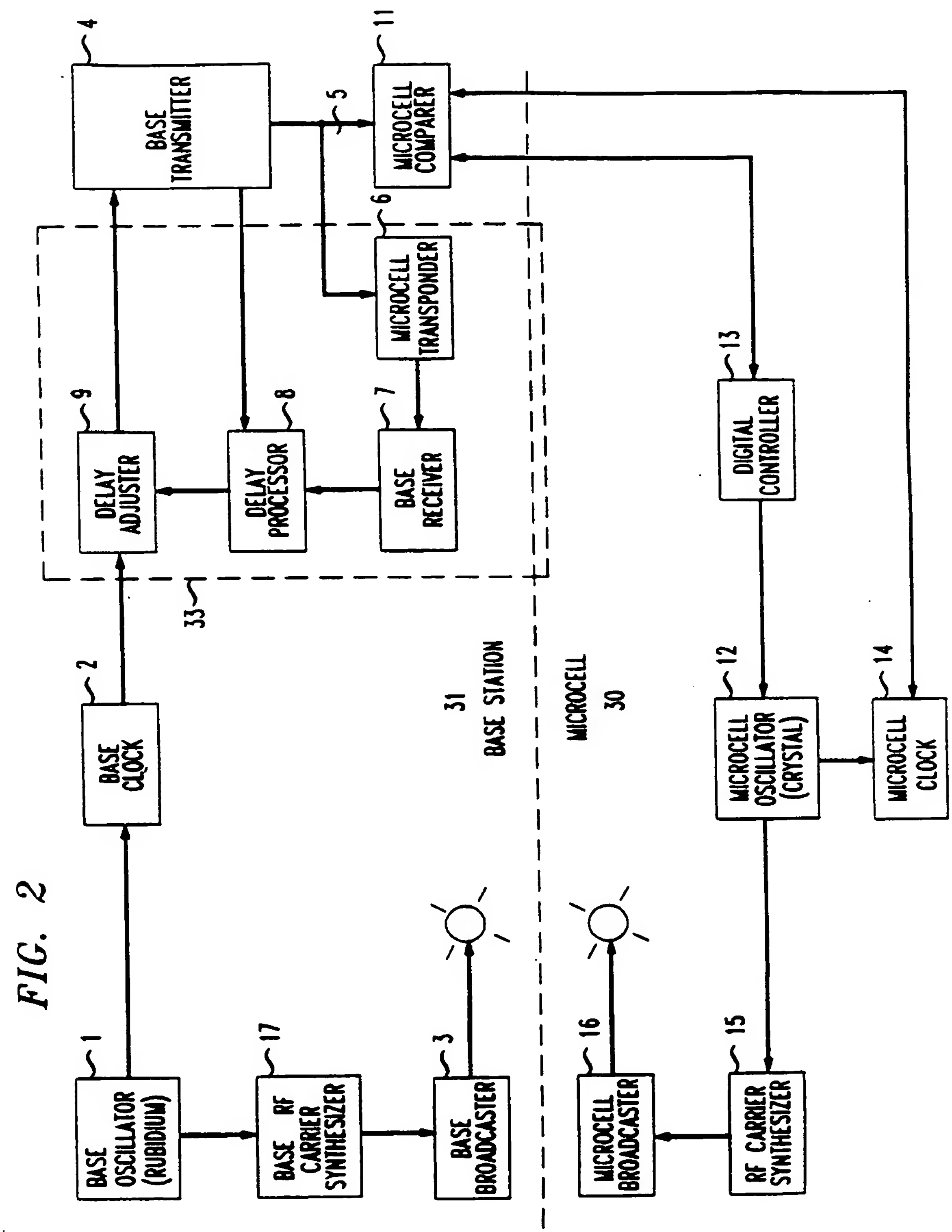

BASE OSCILLATOR (RUBIDIUM)
BASE CLOCK
BASE TRANSMITTER
MICROCELL COMPARER
MICROCELL TRANSPONDER
DELAY ADJUSTER
DELAY PROCESSOR
BASE RECEIVER
BASE RF CARRIER SYNTHESIZER
BASE BROADCASTER
31 BASE STATION
MICROCELL 30
DIGITAL CONTROLLER
MICROCELL OSCILLATOR (CRYSTAL)
MICROCELL CLOCK
MICROCELL BROADCASTER
RF CARRIER SYNTHESIZER
1
2
3
4
5
6
7
8
9
11
12
13
14
15
16
17
33

FIG. 2